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PROSTHETIC REPLACEMENT OF TUMOUR-DESTROYED DIAPHYSEAL BONE IN THE LOWER EXTREMITY

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A description is given of a prosthesis for replacement of tumour-destroyed diaphyseal bone in the lower extremity. It can be used in a salvage procedure and as an alternative to intramedullary nailing or plating procedures. The method is not complicated provided that mechanically sound devices are used and technical errors are avoided. The operation time is short and the patients can be mobilized early.

Key words: bone neoplasms; fractures; metallic implants; prosthesis

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Intramedullary nailing or plating of destroyed bone or pathological fractures, alone or in combination with curettage of the bone and filling of the defect with methacrylate or bone transplants, has been reported previously (Douglas et al. 1976, Harrington et al. 1976, Ryan et al. 1976, Sijbrandij 1978, Zickel & Mouradian 1976). The main disadvantages of these methods are that in spite of quite lengthy surgical procedures the tumour is not removed locally and extensive spreading of tumour cells cannot be avoided. The latter may be of importance in metastatic disease when the actual lesion is the only known metastasis. Some reports on metallic implants for replacement of epiphyseal and diaphyseal destructions have been published (Postel & Langlais 1977, Stürz & Refior 1978).

An implant has been used to replace tumour-destroyed diaphyseal bone in salvage procedures in three patients at the Department of Orthopaedic Surgery in Umeå. The first case, operated on in 1974, was ambulant for 2½ years after the operation. The other two were followed up for 8 and 15 months, respectively, after operation. The main advantages of the device are that the tumour can be removed locally, immediate stability of the bone is achieved and spreading of tumour cells during operation is probably minimized.

PATIENTS AND METHODS

Three patients, two with pathological fractures in the femoral diaphysis and one with a tumour lesion in the proximal third of the tibia, were treated with the device. The destructive lesions in the femora were metastases from a carcinoma in the breast in one case and from an adenocarcinoma of unknown origin in the other case. The one in the tibia was from a hypernephroma.

The approximate length of the pathological bone segment is estimated preoperatively from the radiographs in order to produce a prosthesis of adequate length. The body of the implant should be at least 2 cm longer than the radiographically demonstrable destruction. Too short an implant favours insufficient resection of the tumour and loosening of the device in the medullary cavity. The operation is best carried out with the patient on a fracture table in order to control the length and rotation of the extremity. The bony segment involved is removed *en bloc* allowing an adequate margin of macroscopically healthy tissue. The periosteum is left intact to the level of the bone resection in order to avoid major bone necrosis and consequent resorption. The medullary cavity is reamed and tissue taken for histological examination. The stems of the prosthesis

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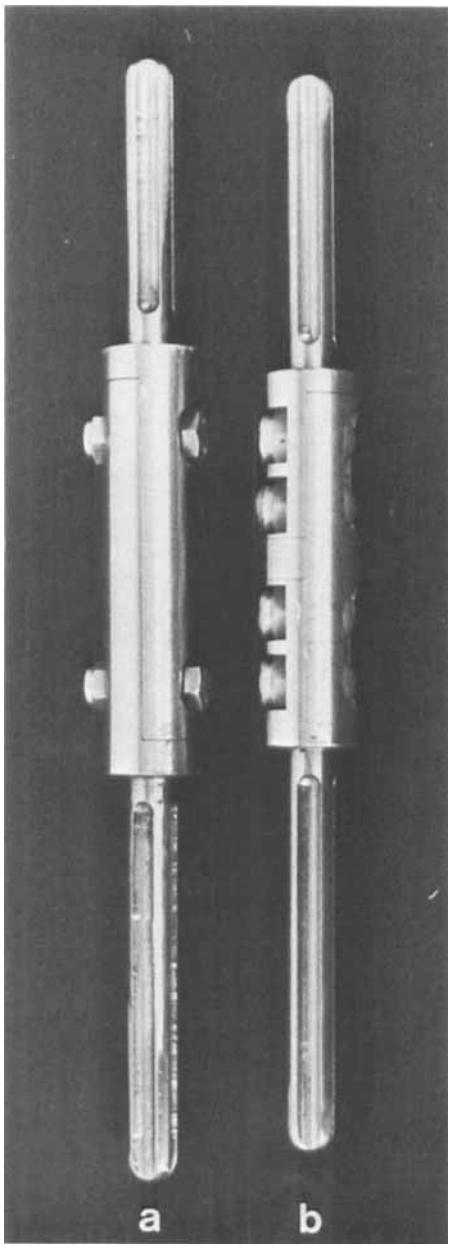

Figure 1. Photograph of the types of diaphyseal prosthesis which have been used. a. The two-part prosthesis. b. The three-part prosthesis.

are inserted as a three- or two-part device to facilitate correct length and positioning (rotation) of the extremity. The stems are cemented with methylmethacrylate. The prosthesis is screwed together using teflon-coated screw nuts.

The prosthesis which was tested in detail was a two-part device tightened by two bolts (Figure 1). The devices were tested in bending in a universal Instron tensile machine at a speed of 0.2 cm/min.

Deformation occurred at one critical point at the root of the stem in this model. Another critical point is at the level of the screw holes where, almost simultaneously, deformation occurs. This is consistent with the behaviour of the prosthesis *in vivo*.

The first case was a 55-year-old woman with a metastasis in the right tibia from a hypernephroma (Figure 2). The size of the osteolytic lesion on the X-ray was 4 × 5 cm. The primary tumour had been discovered and removed about 2 years earlier. It was suspected that another metastasis was located in the distal metaphysis of the right femur. No other metastases were detectable by whole body scintigraphy.

Howmedica's factory in Limerick, Ireland, manufactured a Vitallium prosthesis using the design for a three-part prosthesis of the type described above. The

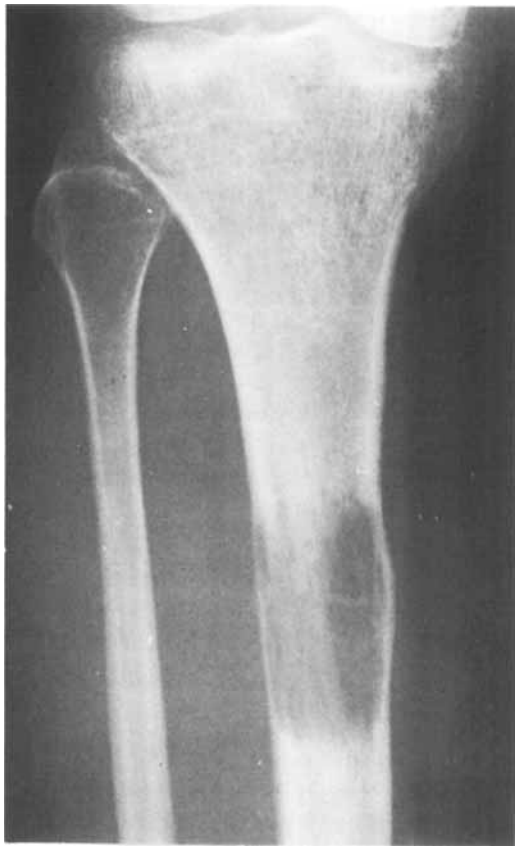

Figure 2. This destruction in the proximal tibia was due to a metastasis of a hypernephroma. The upper border of the defect is situated about 2–3 cm distal to the tuberositas tibiae.

purpose of the three-part construction was to facilitate insertion into the tibia without fracturing the fibula.

At the first operation the osteolytic area was resected allowing a margin of macroscopically normal tissue. The 7 cm long defect in the tibia was replaced with the three-part prosthesis.

Walking exercises were started after a few days, partial weight-bearing allowed after about 1 week and from the 4th week the patient was able to walk without a walking-stick.

One year after the operation the patient experienced instability upon weight-bearing, but no pain. X-ray disclosed bone resorption around the cement in the marrow cavity. At reoperation loosening of the distal stem and fracture of a very thin cement layer in the distal marrow cavity were found. Macroscopically no tumour tissue was visible; however, a biopsy from the proximal marrow cavity again demonstrated tumour tissue. The prosthesis was reinserted after further preparation of the bone and secured using the same bolts and nuts, which was a serious mistake*. The postoperative period was without complications and the patient was ambulating freely after a few days.

After a further 8 months the patient suddenly experienced instability. From the X-rays it appeared that the prosthesis was broken in its proximal part (Figure 3). This time a prosthesis of stainless steel was manufactured in the hospital workshop within 4 days. At reoperation the prosthesis was found to be broken at the level of the proximal screw hole. The nut had loosened most probably because the teflon-coated nut had been re-used at the previous operation. The patient survived another 8 months without problems with the prosthesis. Thus, this patient was able to walk freely for 2½ years following the first operation in spite of complications which in retrospect were at least to some extent avoidable.

The second case was a 70-year-old woman with a pathological fracture in a 3 × 5 cm large osteolytic lesion in the middle of the diaphysis of the right femur. The patient was in relatively good health although X-rays showed pulmonary metastases. The site of the primary tumour was unknown.

The bone destruction was extirpated and a prosthesis inserted in the 9 cm long bone defect in order to mobilize the patient. The implant which was of stainless steel was manufactured within a few days by the hospital workshop. The operation took 1½ hours. Walking exercises with weight-bearing were instituted within 3–4 days. The patient was discharged from the hospital 1 month postoperatively. At that time she could walk with one crutch and without pain. Gradually the patient's condition deteriorated due to progress of the disease and she died 8 months after operation. She never had any discomfort from the operated femur. X-rays during the postoperative period showed unchanged position of the implant and no noticeable resorption around the bone cement.

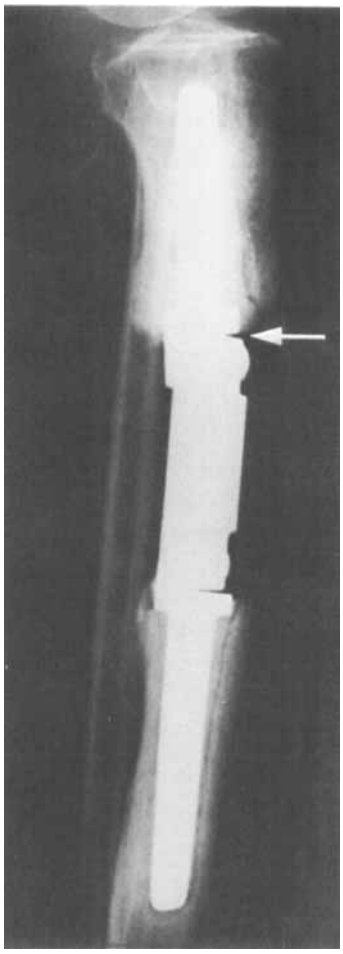

Figure 3. The destruction shown in Figure 2 has been replaced by the three-part prosthesis shown here. The situation illustrated is that 8 months after reinsertion *of the prosthesis (for details see text). Observe the slight sinking of the prosthesis – cement block both proximally and distally. Note the sclerosis of the bone around the tip of the distal stem which should be interpreted as a sign of functional stress.*
At the proximal arrow the prosthesis shows bending at the screw level and the screw was found to be loose at operation. There was also a crack in the material of the prosthesis at the site of the screw hole. There was no loosening of the cement either proximally or distally in relation to the bone.

* The bolts and nuts were of the teflon-coated type and no new ones with correct dimensions were available at the time.

The third case was a 77-year-old woman with a carcinoma of the breast discovered and operated on in 1975.

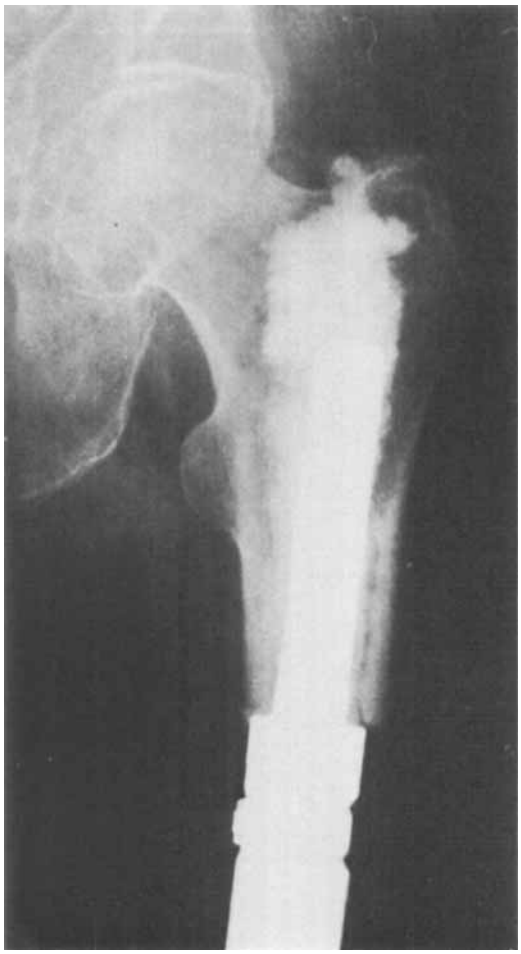

Figure 4. This femur prosthesis was inserted after the first prosthesis in the third case was removed (see text) because of varus bending in the proximal stem. The diameter is larger and the prosthesis is resting on the medial cortex. Note the quite extensive cement mass which was inserted in an attempt to get maximum weight distribution.

In April 1978 the patient fell and X-rays showed osteolytic destruction in the diaphysis of the left femur but no fracture. Radiotherapy was started but the patient had another fall and fractured the bone at the level of the osteolytic destruction. A prosthesis with a stem diameter of 10 mm was manufactured. At the operation a 10 cm long diaphyseal femur segment was replaced by the two-part type of implant (Figure 1).

The patient was mobilized on crutches within 2 weeks and was discharged from the hospital 3 weeks postoperatively. At the follow-up examination 6 months later the patient was walking very well with one stick and had no discomfort. However, X-rays showed some varus bending in the proximal stem of the prosthesis.

A new prosthesis was manufactured with a stem 12 mm in diameter and the collar of the stem was broadened to 24 mm in order to obtain better support for the prosthesis on the cortex of the bone (Figure 4). The patient had no problems with the new prosthesis during a further survival time of 9 months.

DISCUSSION

The limited experience obtained with the patients operated on so far was on the whole positive in spite of complications due to mechanical failures. Some of the complications described are clearly avoidable. Two major sources of failures are involved with this type of diaphyseal prosthesis.

The first has to do with the mechanical properties of the prosthesis which must fulfil the basic mechanical requirements at the site of implantation to avoid bending deformations. This study on models and the experience with the limited number of patients disclosed some obviously critical factors, the most important being the dimension at the site of the screw-hole, the diameter of the root of the stem and the collar. The local mechanical stress at a certain point of a long bone during action seems, however, to be obscure and should be studied further.

The other source of failure is loosening of the prosthesis due to bone resorption. In the active younger patient with the tibia prosthesis, loosening was a major problem. Here the anchoring in the proximal, soft, spongious bone and in the distal, rigid, diaphysis may have been responsible for unfavourable mechanical conditions. The femur prostheses showed no tendency to loosen; however, these patients were elderly and perhaps did not use the leg concerned very much. The device is therefore recommended for use in selected cases with diaphyseal destructions, which should be treated actively with local resection and prosthetic replacement as a salvage procedure in order to give immediate stability of the extremity and continued ambulation.

CONCLUSION

Although stabilization of actual or impending pathological fractures of the diaphysis of long bones in the lower extremity may be achieved by intramedullary nails with or without curettage of tumour tissue and using methylmethacrylate as extra support or as a "spacer", it is believed that the procedure described with local resection of the destroyed bone and replacement of the defect by a diaphyseal prosthesis is preferable as a salvage procedure. It is a straight-forward surgical procedure, the surgical trauma and blood loss are minimal and the period of postoperative convalescence is short. Early mobilization on a painless and fully weight-bearing leg can be achieved.

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